SCREENING STUDY FOR WASTE BIOMASS TO ETHANOL PRODUCTION FACILITY USING THE AMOCO PROCESS IN NEW YORK STATE

FINAL REPORT

PART I: NEW YORK CITY

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ABSTRACT AND KEY WORDS

A study team composed of Stone & Webster Engineering Corporation, Stone & Webster Development Corporation, the Energy Authority, NREL, Amoco, NYNEX, and Champion International was formed to explore the potential of locating an Amoco biomass to ethanol conversion facility in New York City for recycling recovered paper. The objective of the study was to select two preferred sites in the City (Part I); a separate study was conducted to select three preferred sites in Upstate New York (Part II). Minimum facility requirements were prepared to identify the Amoco Process characteristics which would affect site selection and economic evaluation. A conceptual design was developed for a minimum size facility processing 500 tons per day (TPD) of paper or wood which would produce 49,000 gallons per day of ethanol and approximately 300 tons per day of lignin solid byproduct. An initial inventory of 74 sites was screened and final sites were selected and evaluated using a Paired Comparison Technique based on thirteen weighted evaluation criteria reflecting environmental and community related issues and economic factors. The Proctor & Gamble and Arthur Kill sites in Staten Island were selected as preferred sites. Capital costs for the process island and balance of plant were developed for 500 TPD and 1000 TPD facilities to show the effects of economies of scale.

Pro formas were prepared and feedstock tipping fees and ethanol prices required for a viable project in New York City were developed. A financial sensitivity analysis indicated that a limited window of opportunity exists for such a project in the City. Champion International provided a business assessment as an alternative feedstock supplier and recommended paper mill waste as a feedstock which allows for a tipping fee as opposed to recovered paper which currently commands a price. NYNEX provided a business perspective as a potential ethanol user for its vehicular fleet as well as a producer of old telephone directories.

KEY WORDS

Amoco biomass to ethanol conversion process

Recycling recovered paper

Minimum facility requirements

Site selection

Pro forma analysis

Business assessment of feedstock supplier

Business assessment of ethanol user

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SCREENING STUDY FOR WASTE BIOMASS TO ETHANOL PRODUCTION FACILITY USING THE AMOCO PROCESS

PART I: NEW YORK CITY PROJECT EVALUATION

FINAL REPORT

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DESCRIPTION OF STUDY

Background

New York City Department of Sanitation (NYCDOS) indicated its intent to solicit proposals in 1994 for a manufacturing facility located in one of the City's five boroughs which uses waste paper as feedstock as a means of minimizing waste and fostering economic development for both residents and businesses. Although the solicitation has been put on hold, it is expected to be issued in 1995. Furthermore, legislation proposed by the Environmental Protection Agency (EPA) may require that at least 30 percent of the oxygenates contained in cleaner-burning gasoline will have to be made from renewable resources (which include waste biomass products).

These two events prompted the formation of a study group composed of Stone & Webster Engineering Corporation, Stone & Webster Development Corporation, the Energy Authority, NREL, Amoco, NYNEX, and Champion International to explore the potential for a New York City biomass processing facility designed to produce ethanol which could be used for transportation fuels. This study for the City (Part I) is followed by a study of sites in Upstate New York (Part II).

Objective of Study

The objective of this study was to identify and evaluate two sites in New York City that could be appropriate for the construction and long-term operation of a financially attractive and environmentally sound waste biomass-to-ethanol production facility using Amoco's biomass conversion technology.

SITE SELECTION

Facility Requirements

The processing facility design for converting biomass to ethanol requires seven principal processing steps, including waste paper/wood storage, pretreatment, enzymatic hydolysis, fermentation, distillation, anaerobic digestion and solids/liquid separation.

Minimum facility requirements were prepared to identify the Amoco Process characteristics which would affect site selection and economic evaluation. These requirements for two types of cellulose bearing feedstock materials, paper and wood, included feedstock quantity, ethanol production rate, solids by-product characteristics, environmental emission characteristics, utilities, personnel, land area and power reliability. A feedstock quantity of 500 tons per day (TPD) was selected as representing a minimum economic facility size. This would result in 49,000 gallons per day (GPD) of ethanol and approximately 360 TPD of lignin by-product. Since the solids by-product of the process has a significant heating value, the study evaluated two approaches, on-site oxidation for local cogeneration of steam and power, and off-site transport of the solids by-product to a solids burning boiler or incinerator. Utility requirements and power generation requirements were developed for each approach as part of a conceptual flow diagram which integrates the processing steps.

Site Cost Estimates

Capital cost estimates were prepared for the basic process island as well for integration with the balance of plant requirements of a generic type installation in New York City. These costs were subsequently made site specific for the two preferred sites.

The capital cost of the process island has been estimated to be $ 68 million for a 500 TPD plant and $ 108 million for a 1000 TPD plant in New York City. The capital cost

of the process island would be approximately the same for paper and wood feedstock.

The total capital cost for a biomass-to-ethanol facility, including the process island, the balance of plant, site improvements, and land costs for processing 500 TPD of feedstock was determined to be $ 139 million or $ 2837/GPD of ethanol with on-site oxidation of the solids by-product, and $ 102 million or $ 2082/GPD with no on-site oxidation. The total capital cost for a plant processing 1000 TPD of feedstock was determined to be $ 223 million or $ 2276/GPD of ethanol with on-site solids by-product oxidation, and $ 169 million or $ 1724/GPD without on-site oxidation. These costs show a saving due to economies of scale of $ 561/GPD with on-site oxidation, and $358/GPD without on-site oxidation. The costs were determined to be the same for paper and wood feedstocks.

Site Screening and Evaluation

An initial inventory of 74 sites was developed for purposes of screening sites to meet Amoco's minimum facility requirements and as a basis for discussions with New York City and utility agencies as to their availability. Following discussions with the agencies, sites were excluded that were either not available or did not meet minimum facility requirements. This process resulted in an inventory of 24 sites.

In order to identify two preferred sites in New York City for further detailed economic studies, numerous environmental and community related issues were reviewed, screened, and selected as key threshold and evaluation criteria. To qualify for further evaluation, sites were required to meet five threshold criteria, including size, shape, natural resources, availability and zoning. Thirteen evaluation criteria, which enabled comparison of sites, were grouped into four categories, including land use, environmental receptors, transportation, and economic factors. The evaluation criteria were also weighted using the Paired Comparison Technique (PCT), a scientific method for ranking sites by comparing only two sites at a time.

The site selection process resulted in the identification of two preferred sites that ranked among the top five sites. These sites, the Proctor & Gamble (P&G) and Arthur Kill sites are privately owned and are located on Staten Island. Privately owned sites are recommended because of the reduced permitting time over a publicly owned parcel which can only be acquired after lengthy Uniform Land Use Regulatory Procedures (ULURP) are completed by New York City.

COST ESTIMATES FOR PREFERRED SITES

Capital costs for a 500 TPD plant constructed at the two preferred sites were estimated for the conditions of on-site as well as off-site oxidation of the solids by-product. The cost of a plant with on-site solids by-product oxidation at the P&G site is $ 135 million, whereas the comparable cost at the Arthur Kill site is $ 129 million. Similarly, the cost of a plant without on-site oxidation at the P&G site is $ 101 million, compared to the cost at the Arthur Kill site of $ 95 million. The principal cost difference between the two sites is the cost of land. The Arthur Kill site is owned by Con Edison who is prepared to make the site available for virtually no cost in support of the City's interest in a manufacturing facility to recycle paper.

FINANCIAL EVALUATION

Pro Formas

Pro forma analysis was conducted for the biomass-to-ethanol facility to evaluate financial viability and risk. Twelve options were evaluated for each feedstock type of waste paper and waste wood. Two sizes were evaluated to determine the effect of economies of scale: 500 TPD and 1000 TPD. Within each size, two basic plant configurations were distinguished: a biomass facility with an on-site oxidation plant that converts solids by-product to power and steam used within the facility; and a biomass facility which disposes of the solids by-product off-site and purchases all facility energy needs from

local utilities. The market price for ethanol was assumed to fall within a range of $1.20/gallon to $1.50/gallon. A required return of 20% on equity, after taxes, was used for 10 and 20 year life cost evaluations.

Sensitivity analysis was conducted to show the effects of capital costs as well as O&M costs on the financial evaluation. The effects of economic incentives, both from the City as well as State and Federal, were evaluated.

The pro forma evaluation determined the required feedstock tipping fee for the waste paper options and the required ethanol price for the wood waste options. For a paper waste 500 TPD plant, the required tipping fee ranges from $38/ton to $97/ton, showing that revenue from feedstock tipping is necessary for a financially viable project, producing ethanol for $1.20 to $1.50/gallon. Similarly, for the 1000 TPD plant, tipping revenues are required, although for a smaller fee. The required tipping fee ranges from $6/ton to $67/ton, demonstrating the significant economies of scale in capital and operating costs. For the wood waste options, the required ethanol prices always exceed $1.50/gallon. The 1000 TPD plant, with on-site oxidation of the byproduct, produces ethanol for the least cost, $1.87/gallon, when the wood feedstock cost is $20/ton.

The sensitivity analysis indicates that reductions in capital cost of a 500 TPD paper to ethanol plant, on the order of 30 to more than 100 percent, are needed if the project is to be viable on ethanol sales alone at $1.20/gallon. If ethanol can be sold for $1.50/gallon, the necessary capital cost reductions are less onerous, ranging from 7 to 80 percent. The 1000 TPD plants require smaller capital cost reductions.

Just as with the capital cost reductions, O&M costs would have to be reduced by 50 percent to over 100 percent for the ethanol sales at $1.20/gallon to adequately and profitably cover the project costs. A reduction of 10 to 70 percent is required when ethanol can be sold for $1.50/gallon.

Sensitivity of the required ethanol price to variations in capital cost and in total O&M cost were evaluated for the wood waste options for prices of $20/ton and $40/ton. The results indicate that reductions of 25 to over 100 percent are needed if wood costs $20/ton, and 50 to over 100 percent are needed if wood costs $40/ton. Similar results occur for the O&M costs.

Economic cost incentives may reduce tipping fees by as much as $30 to $40/ton; but, in order to achieve these benefits, a facility must be located in an Economic Development Zone to take advantage of State allowed investment credits.

The conclusion of the pro forma analysis is that there is a limited "window of opportunity" for a project such as this, sited in New York City. The project should be as large as possible, and be able to take advantage of economic incentives. The facility with an on-site by-product oxidation plant appears to be more financially viable, due to the high energy costs in the area.

Business Interests

Potential business interests for the proposed waste biomass-to-ethanol production facility were identified from land owners, feedstock suppliers, end product users, solid waste by-product consumers, and the financial community.

Con Ed has offered its site at the Arthur Kill in Staten Island in support of the City's interest for a manufacturing facility to recycle paper.

The principal feedstock supplier is anticipated to be New York City through the Department of Sanitation's collection of recyclable waste paper. The City has prepared a draft RFP for manufacturing facilities located within the City to process the waste paper to a usable product, and has offered City-owned sites and tax incentives for such a facility.

NYNEX Corporation has indicated a strong interest in using the ethanol end product as a gasoline additive in its vehicle fleet as a response to the mandated use of oxygenated gasoline required by the Federal Clean Air Act by January, 1995.

Various utilities and companies which burn municipal solid waste (MSW) were interviewed to gauge interest for processing the solid waste byproduct from the Amoco process as a fuel source. Companies which burn MSW such as American ReFuel would consider the byproduct in the same light as municipal waste and require a tipping fee of the order of $50/ton. Public Service Electric and Gas of New Jersey expressed reservations for processing the by-product from New York City due to political uncertainties for accepting out-of-State waste, new permitting requirements, and unknown effects on the existing boilers.

Based on the financial pro forma runs, it was decided to delay contact of the financial community for equity interests at this time. An improved capital cost structure for building a facility in New York City is required to assure attractive returns on investments commensurate with operating requirements including stable feedstock costs/tipping fees for recycle paper.

BUSINESS ASSESSMENTS

Feedstock Supplier

Champion International perceived the Amoco process as a recycling process which competes with present practices by the paper industry. The paper industry has achieved national paper recovery rates of approximately 40%. The economics of achieving this rate is demonstrated by the Industry's ability to absorb current recycle paper price increases, to over $100/Ton in New York State. Champion indicated that such instability in price makes it currently unfavorable to recycle paper via the Amoco Process. A recommendation was provided that paper mill sludge would be a more suitable feedstock,

particularly in New York State where approximately 400 dry tons/day of paper sludge are generated and landfilled.

Feedstock Supplier/Ethanol User

NYNEX approached the business assessment of the Amoco Process as a potential user of ethanol for its vehicle fleet and as a potential supplier of feedstock in the form of old telephone directories (OTD).

With approximately 4,000 of NYNEX's 12,000 New York State vehicles located at 35 sites throughout the five boroughs of New York City, an Amoco ethanol facility located in the City would appear to offer efficiencies for providing fuel to at least one-third of the NYNEX New York fleet. However, questions related to transportation, storage, and the Amoco intermediate distribution process itself remain to be answered.

Currently, old telephone books are included in the residential curbside program and are a mandatory item in the City's commercial recycling program. Waste paper markets are presently very strong, with prices in the $ 70 to $ 100 range. Therefore, it appears unlikely that OTD will be a feedstock source for the Amoco process in New York City.

Regarding the NYNEX decision on alternative fuels for its vehicle fleet, review of EDA reports confirmed the benefits/costs associated with alternative fuels. However, more research is needed to determine such issues as optimum engine configuration, fuel metering systems, and fuel storage technology.

INTRODUCTION

STUDY BACKGROUND

Interest exists at the New York City Department of Sanitation (NYCDOS) in projects that would minimize waste and foster economic development for both residents and businesses. In New York City, the largest curbside recycling program in the country serves 3 million residences and expects to collect 1300 to 2200 tons per day (TPD) of waste paper by the year 1995. NYCDOS intended to solicit proposals in 1994 for a manufacturing facility located in one of the City's five boroughs which uses waste paper as feedstock. However, because of political and budgetary decisions related to the collection of residential mixed paper (RMP), the solicitation has been put on hold. NYCDOS is working hard to come up with a plan for collecting RMP by July, 1995. A new proposal solicitation for a recycling facility for recovered paper will be prepared at that point. In addition to waste paper, one million tons per year of waste wood chips are collected in metropolitan New York City.

Legislation proposed by the Environmental Protection Agency (EPA) may require that at least 30 percent of the oxygenates contained in cleaner-burning gasoline will have to be made from renewable resources (which include waste biomass products). Thus the market for biomass products, such as ethanol, are expected to increase substantially.

For these reasons, Amoco, together with NREL, NYNEX, Champion International, and Stone & Webster Engineering Corporation have been exploring the potential for a New York City biomass processing facility designed to produce ethanol which could be used for transportation fuels. Amoco has developed its biomass conversion technology through 15 years of research and development (R&D) and pilot plant work by its own staff, NREL and other collaborators. Efforts are underway to assess project feasibility in conjunction with large-scale paper, forest products and agricultural operations.

Application of Amoco's process is particularly facilitated in localities, such as New York City, with a waste paper recycling program.

OBJECTIVE OF STUDY

The objective of this study is to identify and evaluate two sites in New York City that could be appropriate for the construction and long-term operation of a financially attractive and environmentally sound waste biomass-to-ethanol production facility using Amoco's biomass conversion technology.

STUDY ORGANIZATION

The study was managed by Stone & Webster Engineering Corporation (SWEC) with technical support from Amoco, Stone & Webster Development Corporation, NYNEX, Champion International, National Renewable Energy Laboratory (NREL), the Energy Authority and other parties. The following identifies participation of the team members in selection of preferred sites and evaluation of project viability in New York City.

Stone & Webster Engineering Corporation provided the overall management of the study and preparation of this report. In addition, SWEC was responsible for site selection (Section 1), including screening potential sites in New York City, defining site improvement requirements and costs, defining key site evaluation criteria, and evaluating and ranking sites to determine the preferred two sites. SWEC also developed refined budgetary capital and operating costs for the two preferred sites (Section 2) and identified potential business interests (Subsection 3.2).

Amoco defined process-related requirements for the biomass to ethanol production facility (Subsection 1.1) and estimated capital and operating costs for the island of process equipment for 500 and 1000 TPD of feedstock (Subsection 1.3).

Stone & Webster Development Corporation prepared financial Pro Formas for the construction and long-term operation of an Amoco Process facility (Subsection 3.1).

Champion International prepared a business assessment from a feedstock supplier (Subsection 4.1)

NYNEX prepared a business assessment from a potential ethanol user (Subsection 4.2).